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DISCOVERY

Level of service (LOS) determination for a selected round about in Akure metropolis using HCM methodology and critical lane flow analysis

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ABSTRACT

Roundabout is a road transport facility that helps to resolve conflict at road network and a comprehensive philosophy is needed to evaluate the intricate traffic flow movement at an already existing intersection. The most important element of operational performances of roundabout intersections is the capacity and level of service (LOS) of the existing facility. Which is often articulated in terms of degree of saturation expressed in demand volume over capacity ratio (v/c) of 0.85 and the standard geometric features. This paper presents the evaluation of a specific roundabout in Akure, Ondo State, Nigeria. Data used for the analysis was collected through live surveillance method by the assistance of trained undergraduate to use video camera for data capture, actual traffic flow along the roundabout were collected. The technique adopted for the evaluation is based on the highway capacity manual 2010 approach, which evaluates the entry capacities of roundabouts based on each lane this method uses roundabout geometry and users' behaviours which in turn eliminates some roundabout geometric elements not found on the selected roundabout in the study

area. The Level of service by lane was determined for each leg of selected roundabout and it was discovered that the level of service is good, which is gradated as (C) for the eastbound lane and (A) for south and Northeast bound respectively, this is due to the influence of moderate traffic flow around the roundabout, the analysis of the results obtained in real time reveals the need for steady collection of traffic flow data for roundabout intersections so as to obtain regular appraisal of traffic furniture on major routes in a city in order to ascertain their functionality.

Keywords: Traffic, Level, Service, Roundabout

1. INTRODUCTION

The traffic rotary or a rotary intersection is an enlarged road intersection where all converging vehicles are forced to move round a large central island in one direction before they are allowed to weave out of traffic flow into their respective lane radiating from the central island. The main reason for providing a rotary is to eliminate the necessity of stopping the crossing stream of vehicles and to reduce the area of conflict in such a case a vehicle is allowed to merge into one stream around the rotary and then diverge out to the desired lane or direction radiating from the rotary (Gupta & Amit, 2008).

Roundabouts have fewer conflict points. A standard four-legged intersection of two-lane roads has 32 potential conflict points, whereas a roundabout constructed at the same intersection would only have 8 conflict points (Robinson, Rodegerdts, Scarborough, & Ki, 2000).

The at-grade intersections form over 90% of the road network systems in the nation's highway system of these intersections, the conventional roundabout is one of the most effective, efficient and safe intersections found in urban areas. Its strength lies in their ability to reduce the number of vehicular conflicts at intersections and thereby enhance intersection capacity and safety. There are additional intangible benefits of roundabouts such as their traffic calming effect, gateway feature and aesthetics. Although on the rise, adoption of modern roundabouts as a common intersection form is hindered by the general lack of suitable analysis tools that can be used to evaluate their operational performance and thereby facilitate an objective comparison between them and other intersection control strategies.

2. LITERATURE REVIEW

Brown, (1987), observed that the first thought of revolving procedure (i.e rotary intersection) was conceived by Eugene Henard in 1903, where all the traffic would be required to circulate in one direction. The earliest practical use of a rotary system was in New York in 1905, it was named the Columbus Circle and was mounted by William Phelps Eno. The first rotary system in Paris at the Place De l'Etoile was built in 1907. In the UK during 1925 to 1926, rotary system were introduced in London, at Aldwych, Parliament Square, Hyde Park Corner, Marble Arch, and Trafalgar Square. The gyratory operational concept, or 'circus', continued to spread and was frequently recommended for busy intersections of more than four legs. Design was based solely on common sense and experience.

Chen & Lee, (2016) noted that as interests in roundabout applications continue to increase, researchers have raised questions about the effectiveness of existing analytical tools for roundabout planning and design in the U.S. Currently, practitioners rely on studies and software packages from other countries (e.g., United Kingdom and Australia) when designing and analyzing roundabouts. Since roundabout performance is believed to be sensitive to local conditions, such as geometric designs, driving rules (i.e., left-hand drive, right-hand drive, etc.), and driver behaviors, questions about the appropriateness of the applications of international studies and practices in the U.S. have come to the surface.

Belz & Yang, (2018) observed the driver behavior is arguably the largest contributory factor in the performance of a roundabout. This is reflected in the most recent release of the HCM 2010 (1), which provided an update to the calibration process based on local driver behavior and changes in driver experience over time through the use of critical gap and follow-up time. Although there have been significant efforts to expand the knowledge of roundabout operations in the United States, there is still a need for comprehensive data collection and analysis efforts related to driver behavior.

Roundabout performance analyses usually consider two aspects: 1) entrance capacity, 2) operational performance measures (Robinson et al., 2000). Entrance capacity, which is expressed as the maximum flow rate from an entrance approach, concerns the number of vehicles that can be accommodated at a roundabout. Entrance capacity is strongly associated with circulating flow rate, which is the number of vehicles traveling inside the roundabout during the analysis period. On the other hand, operational performance measures, such as delay and queue length, gauge the effectiveness of roundabout service for users (Chen & Lee, 2016).

Study Area (GTB, Alagbaka roundabout)

This is a three legged roundabout that is situated in the commercial center of Akure town, it connects the governor's house on the southern arm and a popular area called the 1st bank area on the western arm and the central bank of Nigeria Akure branch on the northeastern part of the roundabouts, The geometric data obtained are presented in the table 3.10 and the traffic flow data and weaving data for morning and afternoon sections obtained are presented in table 3.11 and 3.12 respectively. The picture in plate 5 shows the roundabout during data collection.

3. METHODOLOGY

According to the (National Cooperative Highway Research Program (NCHRP), 2010) operational analysis of roundabout requires the collection or projection of peak period turning moment volume. Roundabout's geometric and traffic data (peak hour) are required for measuring results. As much as possible, the traffic data collected should indicate the existing peak hour traffic conditions. In order to achieve this, data were collected between the hours of 7.00 am - 9.00am and 3.00 pm - 5.00pm. This time reflects the peak hour for human traffic and various commercial businesses. For existing conventional intersection, these can be determined using data collection techniques such as video recording and field observation and that is achieved in the course of this study after which data for traffic flow of motorcycle was carefully extracted.

Video recording of the entire intersection was done for two weeks, this was achieved by placing the camera close to the under studied roundabout and at a point were all the entry lane of the intersection can be picked. After which manual extractions of the vehicular flow was carried out. First, entry flow for each section were extracted and booked sequentially followed by turning movement, this was extracted from pre-recorded video tape. Each leg was treated differently and the video was played severely to extract the inflow from each section at the entry point and afterward it was played again to obtain the circulatory flow of each vehicle/motorcycle as they were served.

4. RESULT AND DISCUSSION OF GTB, ALAGBAKA ROUNDABOUT

This is a three legged roundabout that is situated in the commercial center of Akure town, it connects the governor's house on the southern arm and a popular area called the 1st bank area on the western arm and the central bank of Nigeria Akure branch on the northeastern part of the roundabouts, The geometric data obtained are presented in the table 1, while the waving pattern for both the morning and afternoon session is presented in table 2 and table 3 respectively.

Table 1 Geometric data of the GTB roundabout.

	1. North Arm	2. South Arm	3. West Arm	4. Northeast Arm
5. Yield at entry (m)	6. -	7. 13.40	8. 15.20	9. 13.80
10. Entry width (m)	11. -	12. 11.80	13. 6.90	14. 8.20
15. Departure Width (m)	16. -	17. 9.20	18. 8.00	19. 8.50
20. Average Circulatory width of the road. (m)	21. 6.70			
22. Central island diameter (m)	23. 9.07			
24. Raise central inland diameter (m)	25. 8.36			

Source: Authors's field work

Table 2 Waving pattern data of GTB roundabout for morning session.

WEAVING PATTERN					
SOUTH ARM		WEST ARM		NORTHEAST ARM	
R_b(PCU/Hr)	L_b(PCU/Hr)	R_b(PCU/Hr)	T_b(PCU/Hr)	T_b(PCU/Hr)	L_b(PCU/Hr)
335	300	372	248	421	305
342	307	362	241	415	300
343	308	385	257	424	307
320	287	352	235	437	317
367	330	406	271	420	304

375	337	408	272	431	312
326	293	377	251	416	301
341	306	411	274	420	304
330	297	376	251	418	303
341	306	398	266	424	307
342	307	385	256	423	306

Source: Authors's field work

Table 3. Waving pattern data of GTB roundabout for Evening session.

WEAVING PATTERN					
SOUTH ARM		WEST ARM		NORTHEAST ARM	
R_b (PCU/Hr)	L_b(PCU/Hr)	R_b (PCU/Hr)	T_b (PCU/Hr)	T_b (PCU/Hr)	L_b (PCU/Hr)
211	136	509	340	459	332
208	133	495	330	459	332
224	144	558	372	455	329
205	131	515	343	458	331
221	142	556	371	500	362
230	148	518	345	503	364
215	138	511	341	493	357
235	151	517	345	515	373
225	145	502	335	456	330
240	154	569	379	501	363
228	146	525	350	480	347

Source: Authors's field work

Using critical lane flow for analysis.
NB = 245 + 361 = 606veh/h just sufficient for a single lane roundabout.
EB = 541 + 369 = 910veh/h just sufficient for a single lane roundabout.
WB = 511 + 245 = 756 veh/h. just sufficient for a single lane roundabout.

Using HCM 2010 for analysis
Highway capacity manual 2010 is also use to analysis the GTB roundabout the result of the analysis is shown in table 2. Show the summary of the analysis.

Table 4 Show the summary of the analysis

Roundabout location	Approach	Entry Flow(PCE)	Capacity	Circulating Flow	95th Percentile Queue	Degree of Saturation V/C	Level of Service
GTB Roundabout.	South (NB)	402	787	361	1	0.31	A
	West (EB)	902	781	369	4	0.69	C
	Northeast (WB)	880	888	245	6	0.58	A
Total		2184	2456	975		0.53	B

Source: Authors's field work.

To have a clear picture of the input parameters and the Level of service results relationships has to be developed and carefully observed. There is a linear relationship between total entry flow at intersection and degree of saturation (v/c). Figure 1 clearly shows this relationship with a reasonable R-squared or coefficient of determination, which is 0.89. while Figure 2 shows the diagram of the level of service of the selected roundabout.

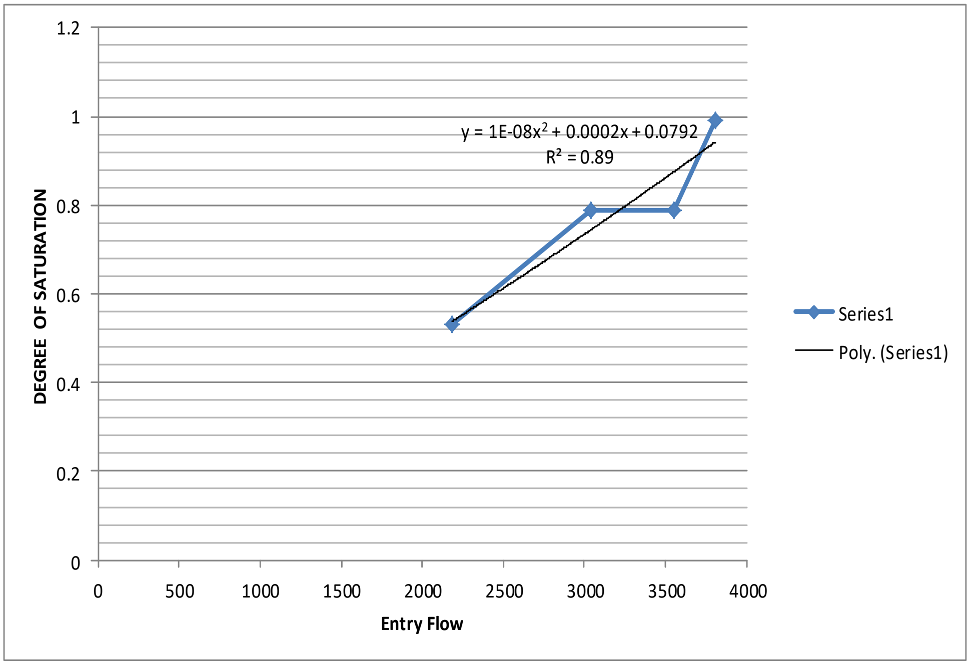

Figure 1 Entry Flow Vs Degree of Saturation for the Intersections.
Source: Authors's Data analyses.

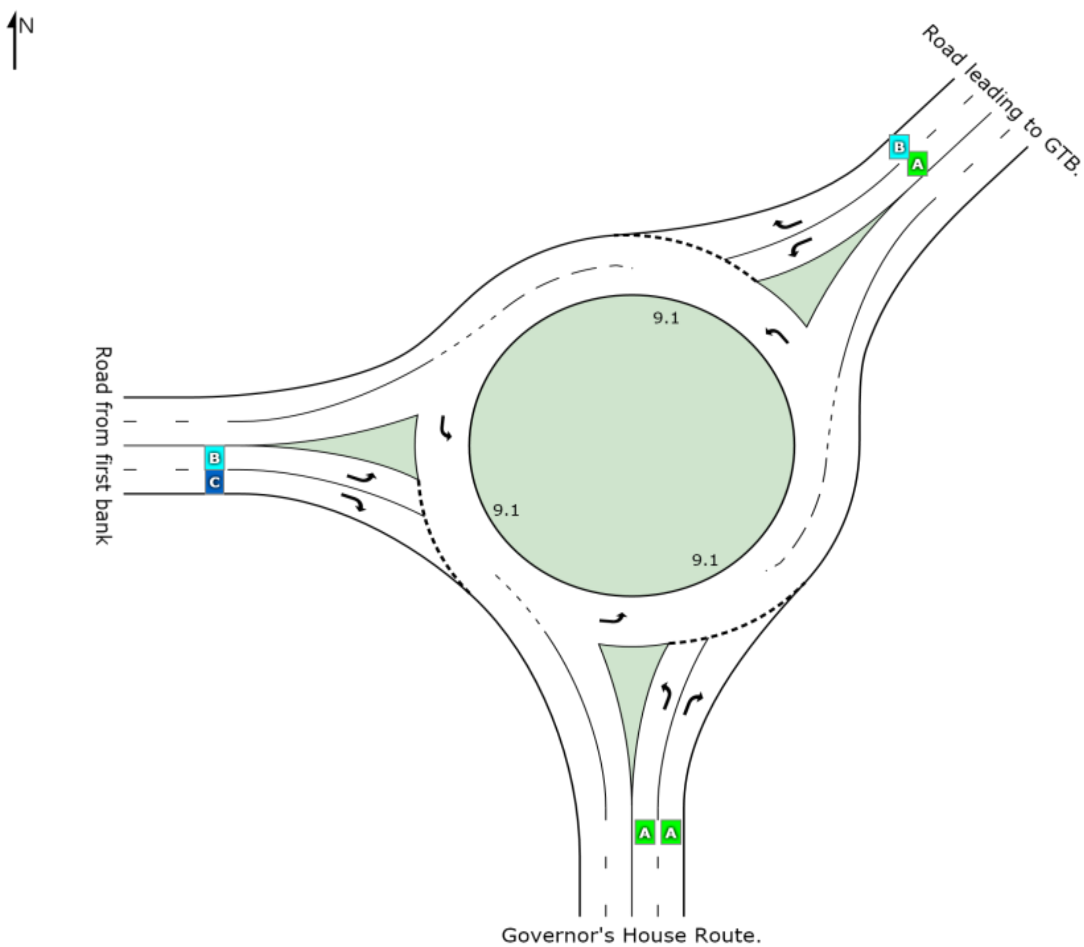

Figure 2 Diagram of the level of service of the selected roundabout.
Source: Authors design 2019

5. CONCLUSION AND RECOMMENDATIONS

Based on observed actual field conditions, it could be deduced that the analysed roundabout is not yet saturated with an average saturation of 0.53 that is why it is common to see that at peak hours, there are no queues at the entry point of these roundabouts. As the study revealed, the major problems that occurs to saturated roundabouts are away related to inadequacy of number of entry lanes, number of circulatory lanes, high traffic flow and unbalanced traffic on the approaches which, in fact, are not recommended for roundabouts. However the west (east bound) lane is gradually getting saturated at peak period. It is recommended that continue monitoring of the lane is important in order to avoid it oversaturation.

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